UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

Cooperative Extension Service

Forage and Pasture

Forage Management Guides

Self-Study Guide Guide 8: Soil Fertility Management in Pastures Essential Nutrients for Plant Growth

Plants need certain elemental nutrients from the air and soil for proper growth an reproduction. Sixteen elements are essential for plant growth. Nutrients are consi to be essential if they are required for plants to grow and reproduce. Plants have different requirements for each essential nutrient. For example, about 96 percent weight of a plant is made up of only three elements - carbon (C), hydrogen (H), a oxygen (O). Plants take up these three elements mainly from air and water. The 4 percent of the weight of a plant comes from the remaining 13 essential nutrient These 13 elements are called mineral elements or nutrients. Plants get mineral nutrients from the soil.

Table 1. Sixteen Essential Elements for Plant Growth

Primary Elements	Secondary Elements	Micronutrients
Carbon (C)	Calcium (Ca)	Iron (Fe)
Hydrogen (H)	Magnesium (Mg)	Manganese (Mn)
Oxygen (O)	Sulfur (S)	Zinc (Zn)
Nitrogen (N)		Copper (Cu)
Phosphorus (P)		Boron (B)
Potassium (K)		Molybdenum (Mo)
		Chlorine (Cl)

Mineral nutrients in soils are found in rock, sand, silt, clay, and organic matter. Sc differ in total nutrient content and also in the amount of each nutrient available for growth. Upland soils such as those in the Ozark and Ouachita mountains are ver in geological terms and are highly weathered. Total mineral content may be high the availability of those nutrients to plants is low. In contrast, river valley soils are geologically young and usually have a higher content of nutrients available for pla growth. The amount of nutrients available in a soil for plant growth can be determ by a soil test.

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The nutrients needed from the soil in greatest amounts are nitrogen (N), phosphc (P), and potassium (K). These are called primary nutrients. Secondary and micronutrients shown in Table 1 are needed in lesser amounts than the primary nutrients. Micronutrients are also called trace elements because they are only rec in trace amounts by plants. Chemical fertilizers are most often used to supply additional mineral nutrients to plants although other sources including organic fertilizers and animal manure can be used, but the nutrient content of these mate should be determined.

Determining the Need for Fertilizer

Adequate soil fertility is required for good forage production. The native soil fertilit level of many Arkansas soils is too low to support the production demands of mo: pasture and hay systems. Fertilizer is applied to increase nutrients available for fc establishment and production above the level supported by the existing soil fertilit level. The amount of fertilizer needed is dependent on the forage species, produc level, and the existing soil fertility levels.

Fertilizer applications for forages should be based on actual conditions for a parti farm instead of "rule of thumb" guidelines or popular opinion. Optimum soil fertilit improves both forage vigor and persistence. While forages often show a growth response to a popular fertilizer rate, that rate likely won't match the nutrient need: specific production system due to differences in soil nutrient levels and nutrient requirements of forage species. Using "rule of thumb" fertilizer rates often leads t much or too little fertilizer being applied - either case being costly to the grower. S tests are excellent tools to use in matching the correct fertilizer rates to the forage production system.

Fertilizer Timing

Fertilizer should be applied to forages just before major periods of forage growth. cool season grasses this can be in early spring or fall and for warm season grass fertilizer is usually applied in late spring. Forage growth can be managed to a deg by proper timing of fertilizer applications. When cool-season grasses are heavily fertilized in the early spring, rapid growth often occurs. If too many acres of cool season grass are fertilized in spring the forage can become coarse and mature b the livestock can graze it. Forage growth can be better matched to livestock neec portion of the cool-season grass acreage is fertilized in spring and the remainder acreage is fertilized in late summer or early fall for fall and winter grazing. Potenti losses of N applied in fall are discussed in the section on nitrogen.

Warm-season grasses such as bermudagrass can be fertilized in late spring and after each harvest if additional forage is needed. The first application should be m when night temperatures are 60? for one week. Legumes such as clover and alfa can be fertilized in spring before growth begins or after haying or grazing. With legumes it is important to build soil levels to medium or high levels to improve sta persistence

Indications of Low Fertility

Accurate fertilizer needs for a crop in a particular field cannot be determined by v observation, however there are some visual indicators that often signal low soil fe levels. Declining forage production, the loss of a forage species from the stand, o appearance of weeds in a field can signal a soil fertility problem. Well fertilized foi are competitive with many weed species. Weed encroachment often becomes se when fertility levels are too low for good forage vigor. The presence or appearanc broomsedge in a pasture or hayfield often suggests the need for limestone since plant becomes competitive with forage plants at low soil pH levels. Note, howeve the presence of broomsedge may also be the result of low soil P and K levels or overgrazing. The increase of broomsedge or other weeds in a pasture indicates t the soil should be tested to determine the proper corrective action.

Information on Soil Test Reports

The routine soil test offered by the University of Arkansas Soil Testing Lab provid analyses for pH, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), sulfate (SO4-S) nitrate (NO3-N), and soluble salts. Fertilizer recommendations are given as poun N - P2O5 - K 2O to apply per acre to reach a specific level of forage production. Limestone recommendations are given as the tons of limestone needed per acre increase the soil pH to an optimum level for the forage to be grown on that soil. N giving specific information regarding fertilizer management are often are printed c report.

Soil tests made on a regular basis can establish a baseline fertility level for a fielc can show changes in soil fertility over time. A baseline fertility level is useful in determining if current fertilizer applications are keeping pace with the amount of nutrients being removed from the field by grazing or hay harvest. Pastures and hayfields should be tested every two to three years to monitor changes in soil fert

Getting a Good Soil Sample

Soil fertility levels will vary over every square inch of a field. Accurate soil test res begin with well-taken soil samples. Poorly taken soil samples result in poor analy results and fertilizer recommendations that do not match the particular field and f There is no best time of year to take soil samples, but samples taken well in adva of the growing season allow adequate time for planning fertilizer and limestone applications.

Composite soil samples should be taken for each field to determine average fertil levels. Generally, composite samples are made up of 15-20 soil cores collected i zig-zag pattern from all across the field. For pastures, each core should be made the soil from the surface down to four inches deep. For fields that will be plowed c should be taken from the plow layer or from the surface down to six inches deep. Representative samples are difficult to collect from hard, dry soil. It is best to colle soil samples when the soil is moist enough to allow good penetration with a soil a or probe.

Generally soil samples should represent 20 acres. Fields larger than 20 acres ca sampled according to the soil type or in units large enough to justify differential applications of fertilizer or lime. Avoid sampling odd areas such as burned bulldo: piles, old barn lots, manure and urine spots, etc.. Soil from these areas can caus biased soil test results and incorrect fertilizer recommendations.

Primary Mineral Nutrients

Nitrogen (N)

Of the mineral elements, nitrogen is needed in the greatest quantity by plants. Pla take nitrogen up from the soil either as nitrate or ammonium. Nitrate is the primar form of N taken up in well aerated soils. Nitrogen is a critical component of protei amino acids. Sources of N are soil organic matter, nitrogen fixation by legumes, fertilizer, and animal manure.

The most common nitrogen fertilizer sources are urea (46 percent N), ammoniur nitrate (34 percent N), and ammonium sulfate (21 percent N and 24 percent S). Enough nitrogen becomes available from organic matter in good grassland soils a year to produce about one ton of grass. Heavy applications of N fertilizer (>100 acre / year) creates soil acidity and lowers soil pH. Low soil pH reduces fertilizer effectiveness. Soils receiving high N rates should be monitored with soil tests to h maintain adequate pH levels.

Minor nitrogen sources such as snow, rain, and atmospheric fixation by lightning provide negligible amounts of N and should not be considered in fertilizer plannin Soil test fertilizer recommendations are given as pounds of actual N to apply per

Nitrogen is perhaps the most transient of the primary fertilizer nutrients. It does n build up in the soil to any appreciable extent like P and K. For good forage growt must be applied just prior to rapid forage growth so that the plants can take it up l it moves out of the root zone or before it is used by other plants. Fertilizer N, depending on the N source, goes through certain chemical reactions in soil.

Urea fertilizer can undergo changes that allow N to volatilize into the air. During c weather, urea and ammonium nitrate fertilizer produce similar amounts of forage pound of N applied. During warm weather, however, N losses from urea can be substantial. When urea is surface applied, it can be converted to ammonia gas b enzyme called urease so volatilization occurs. Urease is found in plant residue o soil surface. Warm temperatures (80 degrees F or above), moist soil, wind, and h soil pH all increase N losses from surface applied urea. Nitrogen losses from surf applied urea can range from very slight to as high as 50 percent. If urea is incorp into the soil soon after application, no N losses occur. Soil incorporation is not pra in pastures so urea is not a preferred fertilizer source for topdressing forages in w weather.

When ammonium nitrate is applied to moist soil, it breaks down into ammonium a nitrate. The nitrate is immediately available to plants. The ammonium fraction is a available to plants, but since it is a positively charged ion, it often becomes attac negatively charged soil particles and becomes unavailable. The ammonium boun soil particles goes through a process called nitrification in which ammonium is converted to nitrate by soil bacteria. The nitrate produced by nitrification is then available for plant uptake.

Nitrogen losses from ammonium nitrate occur only by leaching which can occur i sandy or excessively drained soils during high rainfall periods or by denitrification which occurs when soils become waterlogged. Ammonium nitrate fertilizer does r volatilize when applied to moist or dry soil so it is not lost into the air during hot o weather. For this reason, ammonium nitrate is a desirable material for topdressin forages in summer and early fall.

Phosphorus (P)

Phosphorus is very important for root development. It is also a key element in pla membranes and all energy functions within the plant. Arkansas soils are generall in available phosphorus unless high amounts have been applied as fertilizer or manure. Phosphorus is most available to plants when the soil pH is between 6.0 7.0 (Figure 2) and rapidly becomes tied up with other soil elements such as alum or iron in very acid soils making it unavailable to plants. Phosphorus fertilization h also been shown to increase plant uptake of magnesium (Mg) in tall fescue. Maintaining adequate phosphorus levels in soil then could significantly reduce the of grass tetany in grazing animals. Grass tetany poisoning occurs when forages a too low in magnesium.

The phosphorus content of fertilizers is shown as the percent P2O5 instead of the amount of actual P. Soil test fertilizer recommendations are also made as pounds P2O5 to apply per acre. Common phosphorus fertilizer sources for bulk blended fertilizer include diammonium phosphate (DAP) which contains 18 percent N and percent P2O5, and triple superphosphate (TSP) which contains 46 percent P2O5 no N or K2O.

Phosphorus is an immobile nutrient meaning that it does not leach from the soil. Phosphorus will accumulate in soils when application rates from fertilizer or manu exceed the removal rate in pasture or hay. Fertilizer P applications can be reduce without yield losses when soil P levels build up to high levels. Soil tests should be taken more frequently on high P soils to monitor soil levels when no fertilizer P is applied.

Potassium (K)

Potassium, often referred to as potash, is a critical nutrient for plant growth and persistence. Potassium is involved with transport of N and other nutrients within p All enzymes or proteins in plants are dependent on K. Low available soil K cause reduced forage yields because it is so essential in regulating many functions in th plant. Poor forage persistence is often observed in low K soils. A forage species i yield well for a short period under low K nutrition, but production tends to drop ove time and the forage stand may begin to thin. Winter injury can be more severe in forages growing in low K soil.

Common fertilizer sources of potassium include potassium chloride (60-63 percen K2O) and potassium-magnesium-sulfate commonly called sul-po-mag. Sul-po-ma contains 22 percent K2O, 11 percent Mg, and 22 percent S. Soil test fertilizer recommendations are given as pounds of K2O to apply per acre.

Potassium is also a relatively immobile nutrient in soils, but it can leach a certain amount in sandy soils. Potassium levels can be built up in soils when application exceed removal in the forage. Soils that are high in K should be tested regularly i fertilizer is applied to monitor K levels. High rates of K are removed in hay so soil levels can drop quickly in sandy soils and when fertilizer rates don't match remov rates. High rates of K should be avoided on cool-season grass pastures because nutrient imbalance could occur, resulting in a high potential for grass tetany in gra livestock.

Legumes in Pastures

Legumes are very desirable forages to have in pastures because they are high in nutritive quality, they help offset the effects of fescue endophyte, and they reduce need for nitrogen fertilizer because they can fix nitrogen from the air. Legumes, specifically the clovers and alfalfa, need higher soil fertility levels and careful management to maintain stands than do most grasses. For best establishment ai stand persistence, soil pH and fertility levels should be medium to high before pla legumes. Planting clover into acid, low P soil will often result in a poor to margina stand that dies during periods of stress. Soil pH should be 6.0 or higher and the s level should be at least in the medium range for best establishment. Clovers and especially alfalfa are heavier users of boron (B) and molybdenum (Mo) than are t grasses. These micronutrients should be applied at rates recommended by soil te

Nitrogen should not be applied to grass-legume pastures when legumes are bein established. Nitrogen fertilizer stimulates growth of the established grass enough that it crowds out the developing legume seedling. Nitrogen fertilizer is not neede legumes because in combination with symbiotic bacteria they can fix N from the a Nitrogen fixation is done by Rhizobia bacteria that live in nodules on legume root: crop of alfalfa can fix 200-300 lbs. of N per acre per year. Good stands of red anc ladino clover can fix between 100 and 200 lbs. of N per acre per year. When the percentage of legumes in a pasture is 25 percent or greater, enough N is general available from the legume for adequate forage production without added N fertiliz Adequate amounts of P and K must be applied to maintain good legume stands.

Nutrient Recycling in Pasture and Hay Systems

Currently, there is no distinction of fertilizer recommendations in Arkansas for hay pasture production although the amounts of nutrients removed from a field differs greatly between these two uses. When the hay is harvested virtually all of the nut in the standing portion of the hay crop are removed from the field. Average nutrie removal per ton of hay by various forages is shown in Table 2. Nutrients removec hay can be returned to a field through nutrient cycling only if hay is later fed to live in that field. Nutrient cycling often does not meet the fertility requirements of a ha system so additional fertilizer must be applied to maintain soil fertility levels.

In a pasture system, most of the nutrients in the standing portion of the pasture cı are returned to the soil through manure and urine. Only a small amount of the tot: nutrient content of the forage remains in the grazing animal's body. Manure and ι tend to be concentrated around livestock loafing areas such as shade trees or wa sites so nutrients accumulate in these areas. With a good grazing system, the live can be managed to distribute many of the nutrients in manure and urine back on field to enhance future forage production. Continued uniform distribution of manu and urine on the pasture will improve uniformity of soil fertility over time. As the uniformity of soil fertility improves across the field, less fertilizer is needed to mair production. Fertilizer rates should be based on soil test levels regardless of the gı system being used. Regular soil tests should be taken to monitor fertility levels ar fertilizer requirements.

Table 2. Amount of fertilizer nutrients removed per ton of forage dry mat

	N	P2O5	K2O
	Lbs. removed per ton*		
Alfalfa	58**	14	56
Bahiagrass	31	8	34
Bermudagrass	39	12	44

Bluestems	29	13	56
Clover	43**	12	44
Dallisgrass	34	14	44
Fescue	36	14	50
Legume/grass mix	39**	12	43
Oats	44	4	37
Orchardgrass	44	15	56
Ryegrass	39	16	54
Sorghum/sudangrass	37	14	47
Wheat	36	13	40

*Average of Arkansas forage tests from 1984-96.
**N comes from N fixation not from fertilizer.

Why Forages Sometimes Fail to Respond to Fertilizer

Occasionally forages show very little yield response to fertilizer even though the recommended amount was applied at the proper time. The lack of yield response fertilizer may be caused by several factors. Poor growing conditions are a comm cause for low response to fertilizer. Abnormally cold or dry spring weather can re growth of cool season forages and can delay the early growth of warm-season grasses. If summer-like temperatures arrive before the

plants recover from poor spring growing conditions yields are reduced even more Drought conditions during the summer also reduce yield response of forages eve good fertility management.

Overgrazing reduces the vigor of forage plants. Plants that are overgrazed or gra too frequently have shortened root systems. Weakened forage plants with short r are slower to respond to good growing conditions and fertilizer than healthier plar Low soil pH reduces the availability of many fertilizer nutrients compounding the e of other stresses on the plants. Poorly taken soil samples may not reflect the true fertility level of the field. Fertilizer recommendations based on a poorly taken sam can also cause poor forage yields.

When forage yields are low the amount of nutrients removed from the soil is also fertilizer is applied and the forage crop is a "failure" or very poor yielding, most of and K not removed by the crop will still be in the soil. Phosphorus and potassium to accumulate in soils when application rates exceed removal rates and can impr future forage production.

Fertilizer Grades

Chemical fertilizer is manufactured, mixed, and sold according to fertilizer grades Fertilizer grade refers to the percentage of N, and the oxide forms of phosphorus (P_2O_5), and potassium (K_2O) in the fertilizer product. The practice of reporting phosphorus and potassium as the oxide forms rather than actual P and K in fertili grades dates back to early fertilizer research when P and K were believed to exis these oxide forms. Later research allowed measurement of actual P and K in soil fertilizer, but the practice of reporting these nutrients as the oxide forms in fertilize grades is still used in the fertilizer industry. For consistency, fertilizer recommend for P and K are also given as the oxide forms of P_2O_5 and K_2O.

A granulated fertilizer grade of 17-17-17 for example contains 17 pounds each of P_2O_5 and K_2O per 100 pounds of fertilizer. A potassium fertilizer material used in blended fertilizers having a grade of 0 - 0 - 60 contains 60 pounds of K_2O, but no P_2O_5.

Fertilizer grade should not be confused with fertilizer rate. Fertilizer grade refers t percent or pounds of plant food per 100 pounds of a fertilizer material. Fertilizer r refers to the total amount of plant food nutrients (N, P_2O_5 and K_2O) recommend acre for a particular yield level of forage. For example, a fertilizer rate of 60-90-9(made up using certain amounts of a fertilizer grade or by bulk blending high analy fertilizer materials together. The actual spreading rate refers to the total number c pounds of all the fertilizer materials needed to apply a fertilizer rate per acre.

Bulk Blending of Fertilizer

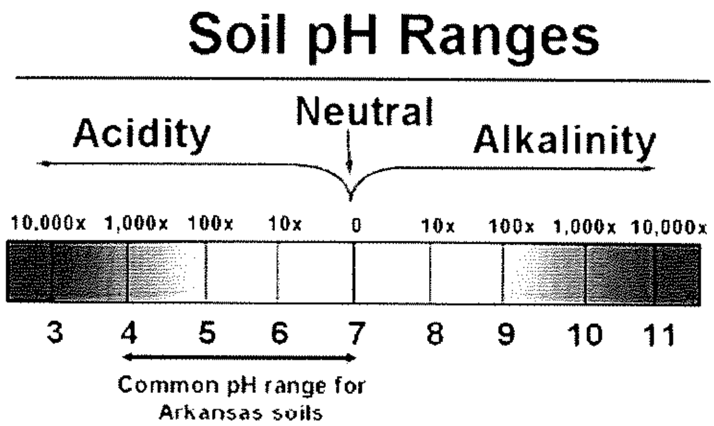
Bulk blending is the mechanical mixing of dry, solid fertilizer materials. Bulk blenc fertilizers have advantages over granulated fertilizers such as 13-13-13. Bulk blei fertilizers can be mixed using high analysis fertilizer materials, which allows the s amount of plant food nutrients to be applied to a field with less weight and transportation costs. For example, 462 pounds of a granulated 13-13-13 fertilizer would be needed to apply a recommended fertilizer rate of 60-60-60 per acre, bu 339 lbs per acre of a bulk blended fertilizer would be needed to apply the same amount of nutrients. The savings in time and transportation costs can be substan when fertilizer is applied to large acreages.

Bulk blended fertilizers also allow more accuracy in nutrient application rates whi reduces costly under- or over-application of specific nutrients. For example, a soi in P may need an establishment fertilizer rate of 25-100-50, but N and K_2O will b over-applied if the P requirement is met by using 13-13-13 or even 17-17-17 fertil Bulk blended fertilizer can be mixed to apply precise amounts of N, P_2O_5 and K_2 thus lowering fertilizer cost by reducing application of unnecessary nutrients.

Importance of Soil pH for Plant Growth

One of the most important soil factors measured is pH. The pH is a measure of th acidity or alkalinity of the soil. Values for pH are based on a scale that ranges fro 14. A pH of 7.0 is neutral. Values above pH 7.0 are alkaline and values below pH are acidic. The pH range for most mineral soils across the U.S. is 3.5 to 10.5 (Fig 1). Most Arkansas soils are acidic and generally range in pH from 4.0 to 7.0. The acidity of a soil increases ten-fold for each whole number decrease below pH 7.0 example, a pH of 6.0 is 10 times more acidic than a pH of 7.0, a pH of 5.0 is 100 more acidic than pH 7.0, and a pH of 4.0 is 1000 time s more acidic than pH 7.0. means that a greater amount of lime is needed to increase the pH of a soil from 4 5.0 than from 5.0 to 6.0.

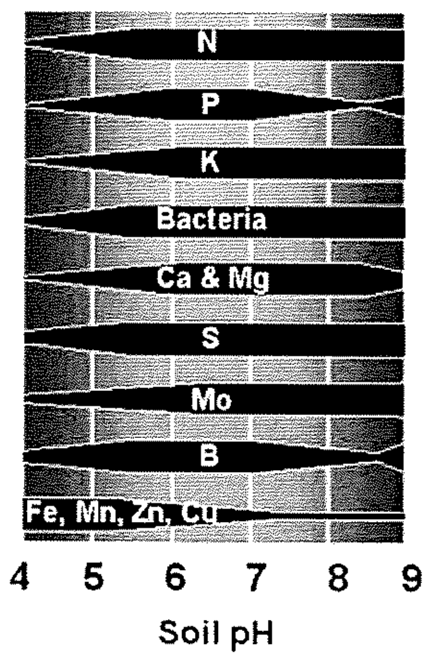
Figure 1. Soil pH Ranges.



Liming Soils

Limestone is applied to soil to neutralize soil acidity and raise the soil pH. Low so can have a dramatic negative effect on forage production. Soil acidity can reduce fertilizer efficiency, nitrogen fixation by legumes, and can lead to micronutrient toxicities (Figure 2). Limestone is made up primarily of calcium carbonate. Limest sources that contain appreciable amounts of magnesium are called dolomite or dolomitic limestone. The carbonate fraction of the limestone material is actually tl material that neutralizes soil acidity. The calcium or magnesium fraction does littl change the soil pH. Soil acidity is caused by hydrogen ions (H+) in the soil. Calci and magnesium ions from the limestone replace acidic H+ ions on the negatively charged soil particle. The carbonate fraction of the limestone then combines with H+ thus neutralizing the acidity and raising the soil pH.

Figure 2. Effect of pH on Soil Nutrient Availability



Liming is most effective if the lime is incorporated into the soil by plowing or diskii Incorporated lime has greater contact with the soil and reacts more quickly to inc the soil pH. In pastures, incorporation of lime is not practical except during pastur renovation so lime must be surface applied. Surface applied lime requires six mo or more to react with enough soil acidity to appreciably increase the soil pH. Lime be applied to pastures during any time of year, but the lag time between lime application and pH change must be considered when planting forages requiring h soil pH levels. Generally, lime should be applied to established pastures in the fal especially if legumes will be overseeded during the winter. Most forages, especia legumes, establish poorly and do not produce well if the soil pH is lower than the optimum range.

Some forages are more tolerant of soil acidity than are others. The optimum pH r varies for different forage crops. The recommended soil pH ranges for forages gr in Arkansas are shown in Table 3.

Table 3. Optimum pH ranges for Forages in Arkansas

Forage Type	Desired pH Range*
Alfalfa	6.4 - 7.5
Alsike and Hop Clover	5.3 - 7.0
Red and white clover	6.0 - 7.0
Grasses	5.5 - 7.0
Lespedeza	5.5 - 7.0
Oats	5.0 - 7.0
Rye	5.5 - 7.0
Sorghum	5.8 - 7.0
Sudangrass	5.5 - 7.0
Vetch	5.5 - 6.7
Wheat	5.5 - 7.0
*Taken from Arkansas Coop. Extension Service Soil Test Recommendation Guide	

Limestone Quality

Limestone effectiveness is determined by the CCE (calcium carbonate equivalen the sieve size percentage or the degree of finely ground particles in the material. CCE of a liming material is determined by reacting the liming material with acid. T amount of acid neutralized by the limestone in this reaction tells the level of CCE lime material. Pure limestone with no impurities would be 100 percent CCE. The standard CCE level for liming materials in Arkansas is 80 percent. Some liming materials may have higher CCE percentages and others may be lower.

Agricultural limestone must be finely ground to effectively reduce soil acidity. Ag l produced by grinding or pulverizing limestone fine enough so that the resulting m will pass through specific sized screens or sieves. A good quality ag lime is typica ground fine enough so that 90 percent of the material passes through a 10 mesh 40 percent passes through a 60 mesh sieve, and 25 percent passes through a 1(mesh sieve. The fineness of the pulverized material does not affect the total solul of a liming material, but it directly affects the rate of reaction with soil acidity. Cou limestone particles have essentially no effect on soil pH. Finer materials have mo surface area and react with soil acidity rapidly, increasing the soil pH. Lime partic coarser than 10 mesh in size have essentially no neutralizing value, those betwe and 60 mesh have 40 percent efficiency, and particles smaller than 60 mesh hav 100 percent efficiency factor.

Arkansas does not have a law requiring a minimum quality level for agricultural limestone, but the lime dealers are required to state the CCE and sieve size percentages of any liming material sold. Values for both CCE and the sieve size percentages should be used when comparing different liming materials. A finely ground liming material with a relatively low CCE can be just as effective in neutra soil acidity as a more coarsely ground material having a high CCE.

Using Manure as a Substitute for Fertilizer

Animal manure can be an inexpensive source of fertilizer nutrients for pasture an production. Animal manures vary widely in nutrient content due to the ration fed t animal, nutrient losses during storage, and moisture content of the manure at application. Laboratory analysis of the manure is recommended to accurately determine the application rate per acre that will supply the necessary amount of nutrients to the forage. If the analytical results are reported by the laboratory on a weight basis, they must be converted to an "as is" basis for calculating applicatio rates. If no laboratory analysis is available, application rates can be based on the average nutrient values of similar manures as shown Table 4.

Table 4. Average nutrient levels of different types of poultry manure

Manure Source	Pounds of nutrients per ton		
	N	P_2O_5	K_2O
Broiler litter at 30% moisture	56	48	36
Caged hen manure:			
At 60% moisture:	30	70	23
At 30% moisture:	52	122	38

Generally about half of the nitrogen in manure is lost to the atmosphere through volatilization when it is surface applied and not incorporated. Little loss of N occu when manure is incorporated in the soil immediately after application. All of the P K in manure is considered to be available to plants over time.

Animal manures can be substituted for commercial fertilizer according to the follo guidelines:

- For surface applied animal manure substitute two pounds of N in animal manures for each pound of recommended commercial fertilizer N. If manure is immediately incorporated into the soil, substitute N from manure on a pound-per-pound basis with recommendations for commercial fertilizer N. Substitute P and K on a pound-per-pound basis with recommendations for fertilizer P and K for both surface applied and soil-incorporated manure. Apply at the beginning of the growing season for the particular crop.

• Limit recommended annual applications of poultry manure and litter depending on soil test P and K values shown in Table 5.

Table 5. Recommended poultry litter application rates based on soil test P a

Soil test P (lbs./acre)	Maximum litter or manure application (tons/acre/year)			Soil test K (lbs./acre)	Maximum litter or man application (tons/acre/y		
	Broiler litter @ 30% moisture	Hen litter @ 60% moisture	Hen litter @ 30% moisture		Broiler litter @ 30% moisture	Hen litter @ 60% moisture	H lit @ : moi:
above 300	0	0	0	above 800	0	0	
210-300	1-2	1-2	1	501-800	1-2	1-2	
121-200	2-3	2-3	1-2	351-500	2-3	2-3	1
75-120	3-4	3-4	2-3	250-350	3-4	3-4	2
below 75	4-6	4-6	3-4	below 250	4-6	4-6	3

- On cool-season grasses and small grains grown on low fertility soils, limit p litter rates to no more than 4 tons per acre per year, regardless of higher sc fertilizer recommendations, to reduce chances of grass tetany or nitrate poisoning in cattle.

- Where total annual rates are to exceed 4 tons per acre, make split applicat of no more than 2.5 tons per acre. Split applications at least two to three m apart reduce the chances of excessive N and P getting into streams or groundwater. Follow best management practices developed for Arkansas c farm.

- To check for nutrient balance in soil, test the soil at least every two years w high manure application rates are used. Do not apply P from any source wl the soil test P exceeds 300 pounds per acre.
- There is a high risk of grass tetany in cattle grazing cool-season forages wl soil test K levels are above 800 pounds per acre and Ca levels are below 2 pounds per acre.

- When animal manures high in moisture are applied to growing forages, foli: burn often occurs especially in summer when soil moisture is limited.

Information for this guide was taken from: 1998 Arkansas Soil Testing Guide, Bra C. 1974. The nature and properties of soils. 8th ed. MacMillan Publ. Co. New Yor and Tisdale, S.L. and W. L. Nelxon. 1975. Soil Fertility and Fertilizer, 3rd ed. Mac Publ. Co. New York.

For more information about forage management, contact your county Extension c or refer to one of our **publications**.

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